

March 8, 1966

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3,239,193

FLUID MACHINES

Filed June 20, 1963

6 Sheets-Sheet 1

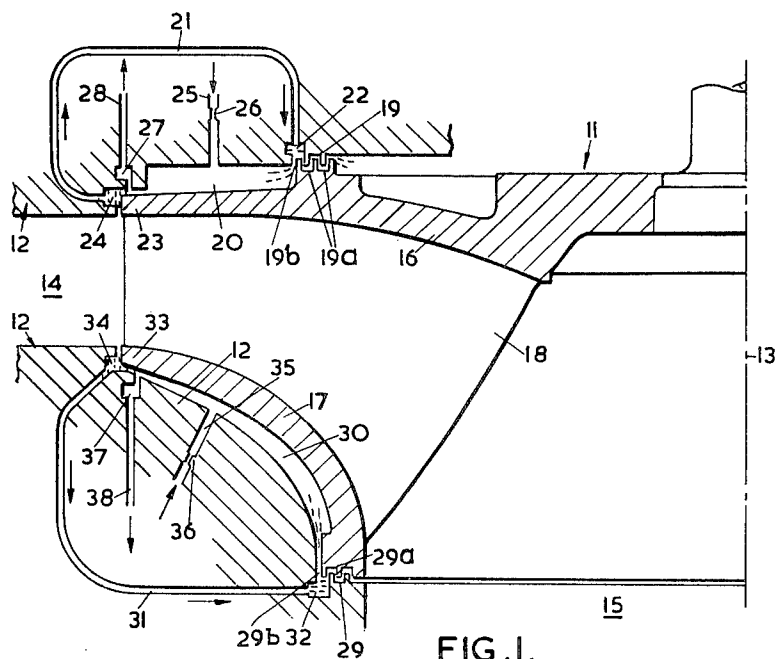


FIG. 1.

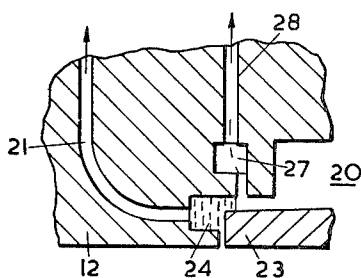


FIG. 2.

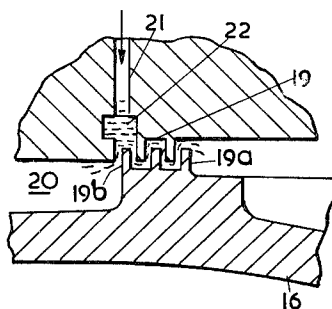


FIG. 3.

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6 Sheets-Sheet 2

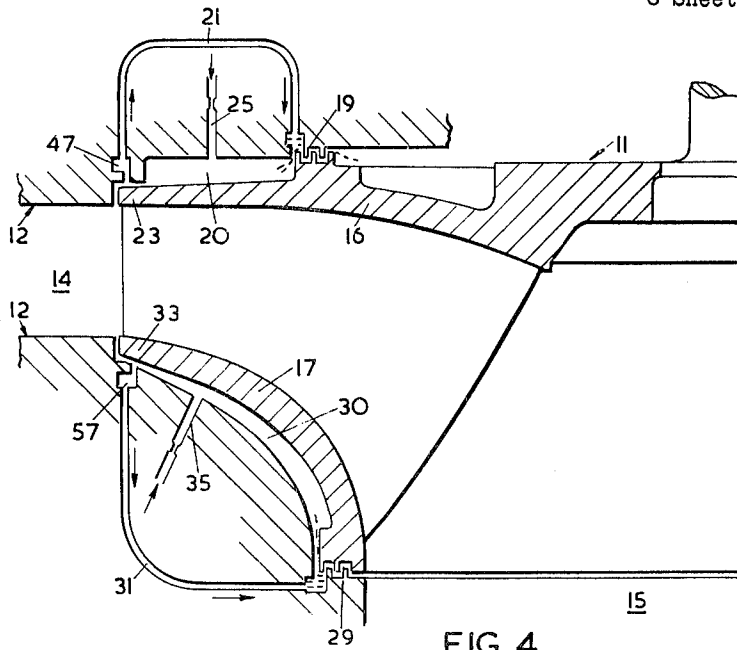


FIG. 4.

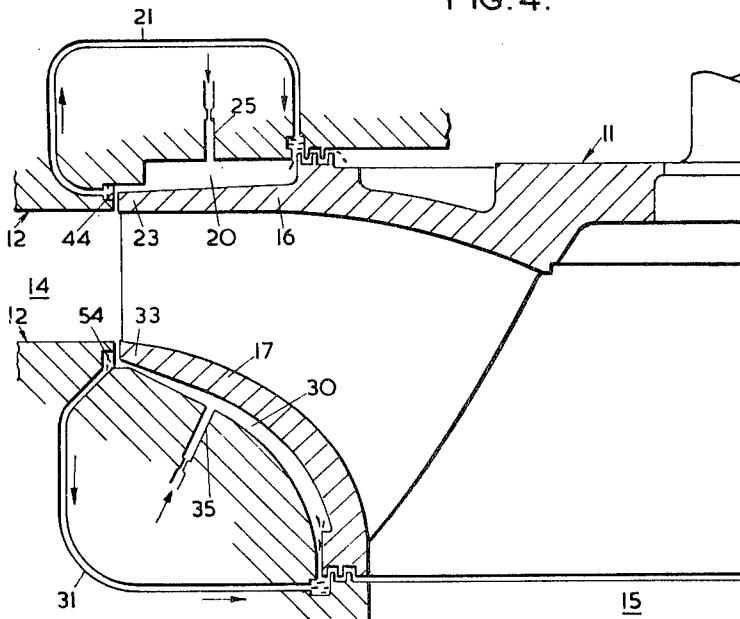


FIG. 5.

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FLUID MACHINES

3,239,193

Filed June 20, 1963

6 Sheets-Sheet 3

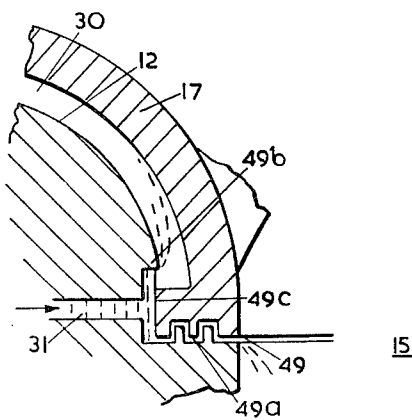


FIG. 6.

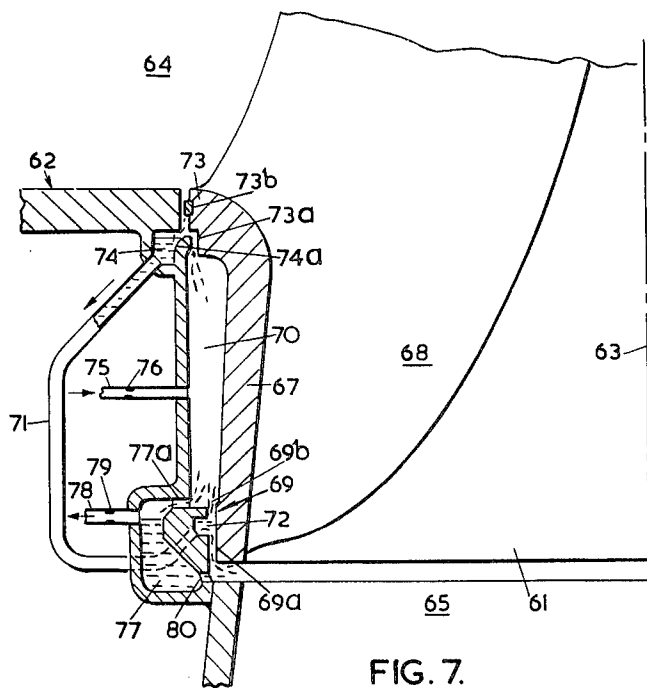


FIG. 7.

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3,239,193

Filed June 20, 1963

6 Sheets-Sheet 4

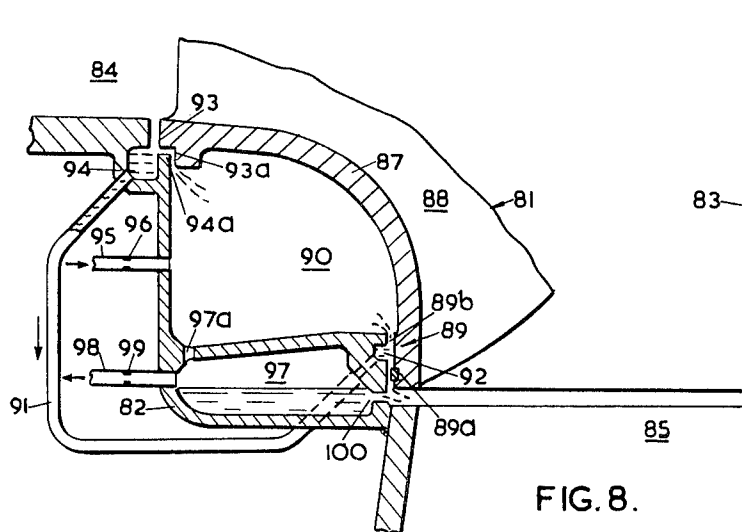


FIG. 8.

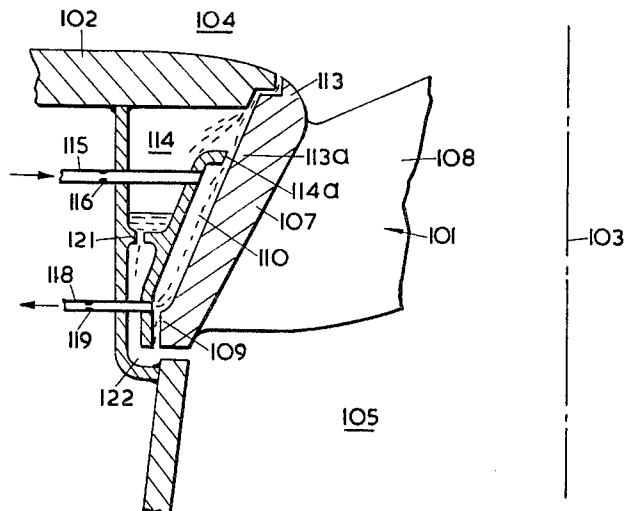


FIG. 9.

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3,239,193

Filed June 20, 1963

6 Sheets-Sheet 5

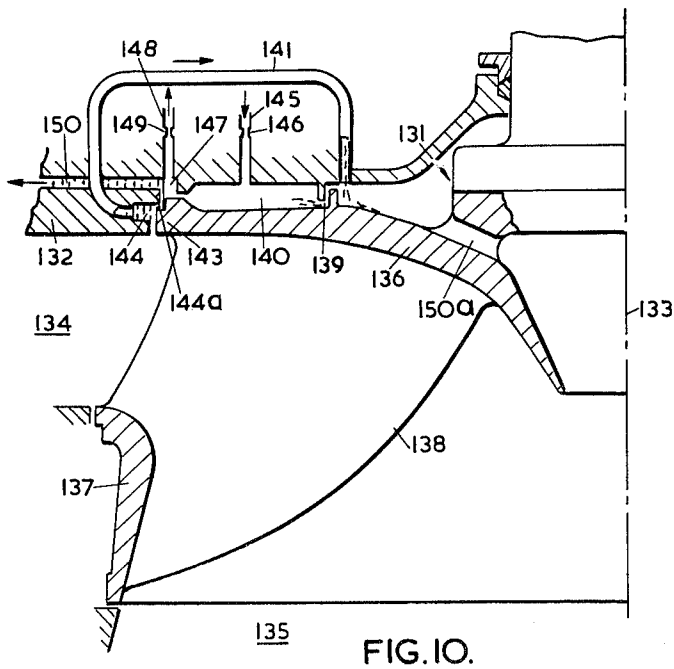


FIG. 10.

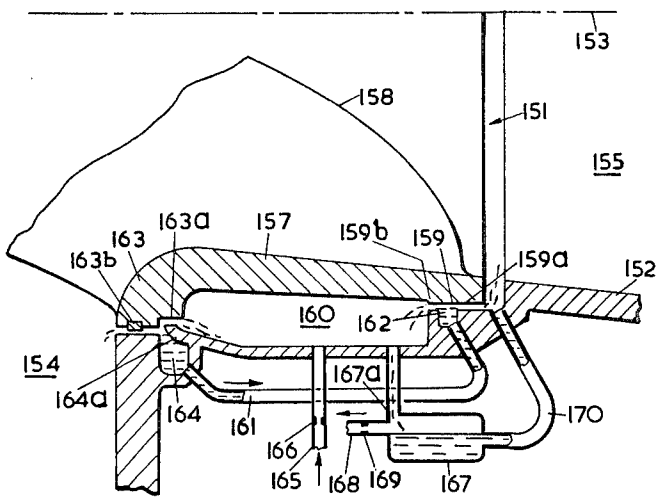


FIG. 11.

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March 8, 1966

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3,239,193

FLUID MACHINES

Filed June 20, 1963

6 Sheets-Sheet 6

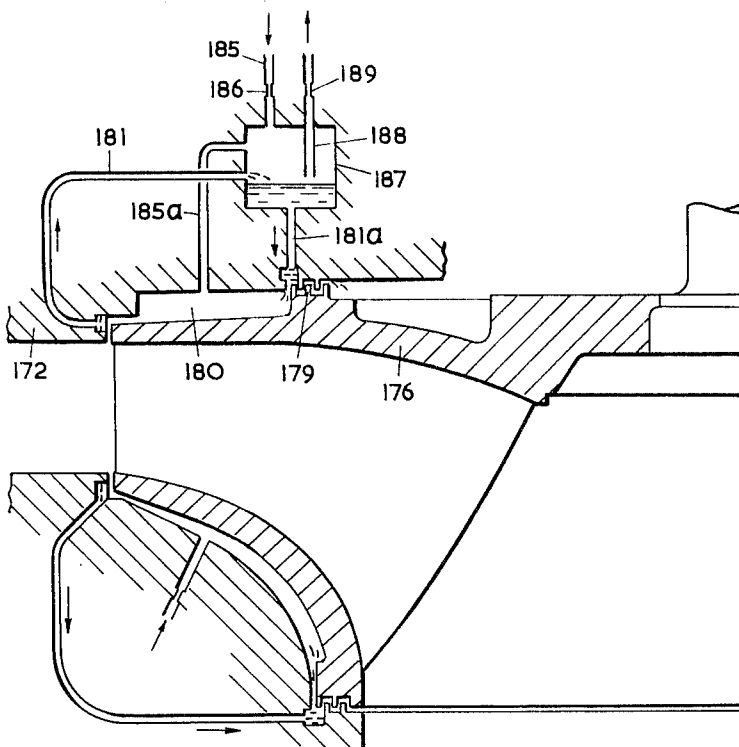


FIG. 12

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1

3,239,193

FLUID MACHINES

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Claims priority, application Great Britain, July 3, 1962, 25,515/62, 25,517/62; July 16, 1962, 27,217/62, 27,219/62

9 Claims. (Cl. 253—26)

This invention relates to fluid machines.

Such fluid machines include pumps, turbines, and reversible pump turbines.

According to this invention a fluid machine comprises a runner, stator structure co-operating with said runner to afford a space therebetween, sealing means between said runner and said stator structure at the end of said space adjacent the low-pressure side of the runner, said sealing means comprising co-operating parts on said runner and on said stator structure and means to supply liquid to said co-operating parts in such a way that the pressure of the liquid is higher than the pressure in said space, whereby to prevent the escape of gas from said space between said co-operating parts, means to supply gas to said space under a pressure greater than that equivalent to the head of water of the machine, and means for by-passing the major part of the working fluid leakage from the high-pressure side of said runner to the low-pressure side thereof, or to drain, without passing through said space.

Preferably conduit means is provided for the escape of excess gas or liquid mixed with gas from said space, but alternatively the excess gas may be allowed to leak into the working fluid channel.

According to a feature of the invention, said means to supply liquid to said co-operating parts may comprise said means for by-passing the major part of the working fluid leakage from the high-pressure side of said runner. Said means to supply liquid may comprise collector means located adjacent the periphery of said runner and conduit means to convey liquid from said collector means to said sealing means.

According to a preferred feature of the invention, the stator structure adjacent the periphery of the runner may be provided with a lip defining said collector means, and the diameter of the periphery of the runner may be substantially greater than the diameter of the sealing means, whereby liquid in said space is caused to flow by centrifugal force to said collector means, from which it is delivered through said conduit means to said sealing means.

According to another feature of the invention, said stator structure may be provided with deflector means to deflect liquid passing between the periphery of the runner and adjacent stator structure into said collector means, whence it flows through said conduit means to said sealing means.

According to yet another feature of the invention, there may be provided a secondary chamber defined by said stator structure, said conduit means for the escape of excess gas or liquid mixed with gas may communicate with said secondary chamber, and said secondary chamber may also be provided with discharge holes at a level below said means for the escape of excess gas to allow the escape of liquid from said secondary chamber.

A number of embodiments of this invention will now be described by way of example with reference to the accompanying drawings, of which:

FIG. 1 shows an arrangement of pump, turbine or reversible pump turbine embodying the invention, in which the high-pressure end of the runner is of larger diameter than the low-pressure end,

2

FIGS. 2 and 3 show details of the arrangement of FIG. 1, on an enlarged scale,

FIG. 4 shows an arrangement similar to FIG. 1 particularly suitable for a turbine,

FIG. 5 shows an arrangement similar to FIG. 1 particularly suitable for a pump,

FIG. 6 shows a modification of FIGS. 1, 4 or 5 on an enlarged scale,

FIG. 7 shows another arrangement of pump, turbine or reversible pump turbine, in which the diameters of the high-pressure and low-pressure ends of the runner are similar,

FIG. 8 shows yet another arrangement of pump, turbine or reversible pump turbine,

FIG. 9 shows an arrangement of turbine, in which the high-pressure end of the runner is of similar diameter than the low-pressure end,

FIG. 10 shows an arrangement of pump, turbine or reversible pump turbine,

FIG. 11 shows another arrangement of pump, turbine or reversible pump turbine, and

FIG. 12 shows yet another arrangement of pump, turbine or reversible pump turbine.

Referring now to FIG. 1, there is shown an arrangement of pump, turbine or reversible pump turbine which comprises a runner 11 and stationary structure 12. The stationary structure 12 defines a passage 14 at the high-pressure side of the runner, that is, the inlet side in the case of turbine operation and the outlet side in the case of pump operation, in which the flow is substantially at right angles to the axis of rotation 13 of the runner, and moreover the stationary structure defines a passage 15 at the low-pressure side of the runner, that is, the outlet side in turbine operation and the inlet side in pump operation, in which the flow is substantially parallel to the axis of rotation. The runner 11 comprises two shrouds, referred to respectively as the crown 16, and the skirt 17, connected by vanes 18 (only one of which is shown), the crown and skirt defining between them the working fluid passage of the runner.

A seal 19 is provided between the crown 16 and the adjacent stationary structure 12, the seal defining the radially-inner limit of an annular space 20 between the crown 16 and the adjacent stationary structure. The seal 19 is of the labyrinth type (see also FIG. 3) and is supplied with water under pressure through a pipe 21 leading into an annular space 22 which is effectively between the inner and outer ends of the seal. The main portion 19a of the seal lies radially inward of the annular space 22, and a narrow portion 19b of the seal lies radially outward of the annular space 22. A drain pipe is provided in the stationary structure, inward of seal 19.

Water tends to leak between the rim 23 of the crown 16 of the runner and the adjacent stationary structure 12 and this structure is provided with an annular collector 24 (see also FIG. 2). The collector 24 is connected to pipe 21.

A conduit 25 is connected from a supply of air under pressure (not shown) to the space 20, through a restricted orifice 26. The pressure of the air supply should be greater than the head of water in the passage 14 on the high-pressure side of the machine.

There is also provided an annular channel 27 communicating with the space 20 just inward of the rim 23 of the crown of the machine, and connected to waste through pipe 28. The opening of the annular channel 27 into the space 20 is positioned to determine the depth of water in the annular collector 24.

The skirt 17 is provided at its inner diameter with a labyrinth seal 29, corresponding to the seal 19 on the crown, between the lower end of the skirt 17 and the

adjacent stationary structure 12. The skirt 17 defines, with the adjacent stationary structure 12, a space 30, and the seal 29 is at the radially-inner and lower end of the space 30 and seals off the space from the passage 15 at the low-pressure side of the runner.

The seal 29 is fed with water between its inner and outer peripheries from a suitable source of water under pressure through a pipe 31 connected to an annular space 32. The main portion 29a of the seal is radially inward of the space 32 and the outer band 29b is effectively radially outward of the space 32. Adjacent the rim 33 of the skirt 17 the stationary structure 12 is provided with a lip defining an annular collector 34 which is connected to the pipe 31.

A supply of air under pressure is connected to the space 30 through conduit 35 containing a restricted orifice 36. The pressure of the air is greater than that of the head of water in the passage 15 at the high-pressure end of the machine. There is also provided an annular channel 37 which communicates with the space 30 just inwardly of the rim 33 of the skirt and is connected to waste through pipe 38.

In operation of the pump, turbine or reversible pump turbine, the annular collectors 24, 34 fill with water from leakage between the runner 11 and the stationary structure 12 and also from any water entering the spaces 20, 30, which is caused to flow outward by centrifugal force. Water from collectors 24, 34 is delivered through pipes 21, 31 to the respective seals 19, 29, the water sealing the gaps between the runner and the stationary structure and thereby preventing the inward flow of air from the spaces 20, 30. The spaces 20, 30 are filled with air under pressure from the pressure air supply through the respective pipes 25, 35, forcing any water outwards into collectors 24, 34. The boundary between the air in spaces 20, 30 and the water in collectors 24, 34 is determined by the apertures to the annular channels 27, 37 which allow air and any excess water to flow to waste through pipes 28, 38. If the pressure of air in spaces 20, 30 rises, the boundary is forced back (to the left in the figures) and more air escapes through pipes 28, 38. If the air pressure falls, the boundary moves to the right, and a certain quantity of water escapes through pipes 28, 38. In terms of volume air escapes through an orifice substantially 30 times faster than water, so that the outflow of water through an orifice designed for a small quantity of air is negligible.

A modification of the arrangement of FIG. 1 is shown in FIG. 4, which is particularly suitable for a turbine though it may also be used, if desired, as a pump or as a reversible pump turbine. In this arrangement the two annular channels 24, 27, which co-operate with the crown, and those 34, 37, which co-operate with the skirt, are replaced by a single annular channel 47, 57 co-operating with the crown and skirt respectively; the single annular channel is connected to the respective pipe 21, 31.

In this case the level of the water at the periphery of the crown and skirt is determined by the point at which the annular channel 47, 57 opens into the respective space 20, 30, and both water and air will flow into the annular channel 47, 57, from which they are delivered through pipes 21, 31 to the respective seals 19, 29. It will be appreciated that where the machine is used as a turbine the admixture of air in the water fed to the seal 29, which will leak out to the passage 15 on the low-pressure side of the runner, may not adversely affect the operation of the runner, but where the machine is used as a pump it may be found undesirable to have a small leakage of air into the passage 15 adjacent the inlet of the runner.

A further modification of the arrangement of FIG. 1 is shown in FIG. 5. This arrangement is particularly suitable for use as a pump but may, if desired, be used as a turbine or as a reversible pump turbine. In this case the annular channels 24, 27, which co-operate with the

crown 16, and 34, 37 are replaced respectively by a single annular collector 44, 54 co-operating with the crown and skirt respectively. Here again the level of water in the annular collectors 44, 54 is determined by the lip of the stator structure, water flowing into the collectors 44, 54 both from the working fluid channel, and from the respective space 20, 30 under centrifugal action. In this case, however, air supplied to the spaces 20, 30 through conduits 25, 35 leaks out into the working fluid passage 14 at the high-pressure side of the machine rather than into the pipe 21, 31. If the pressure of the air in spaces 20, 30 rises, the boundary between air and water will move to the left, towards the lip of the stator structure, and if the pressure falls the boundary will move to the right, towards the rim 23, 33 of the crown or skirt. Thus where the machine is used as a pump air leaking into the working fluid passage will be downstream of the runner and will not affect its operation, whereas where the machine is used as a turbine air leaking through the gaps between the rim 23, 33 of the runner and the stator structure would flow through the working fluid passage of the runner. In this arrangement the water delivered from the collectors 44, 54 through pipes 21, 31 to the seals is not admixed with air.

Referring now to FIG. 6, there is shown a further modification of the construction of FIG. 1. In this modification, instead of the seal 29, there is provided a seal 49 at the radially-inner periphery of the skirt 17. The seal 49 comprises a labyrinth seal 49a between the base of the skirt 17 and the adjacent stationary structure 12, and a lip 49b of the stationary structure 12 which projects radially inwardly so as nearly or quite to overlap an outwardly-projecting lip 49c on the skirt 17. The water supply 31 is led to the seal between the labyrinth seal part 49a and the lip 49b thus tending to flood this space and thereby to prevent leakage of air from space 30 into the working fluid passage 15 at the low-pressure end of the runner. The rotation of the skirt 17 gives a centrifugal component to the water fed to the seal and the surplus water spills over the lip 49b into the space 30 and is caused by centrifugal action to flow to the outer end of the space.

Referring now to FIG. 7 there is shown a turbine, pump or reversible pump turbine of medium specific speed design, in which the high-pressure end of the runner is not at a substantially greater radius than the low-pressure end. In this arrangement the runner 61 rotates in stationary structure 62 about a centre-line 63. The stationary structure defines a passage 64 at the high-pressure end of the machine, i.e. the inlet in the case of turbine operation and the outlet in the case of pump operation, and the stationary structure also defines a passage 65 at the low-pressure end of the machine, i.e. at the outlet end in turbine operation and the inlet end in pump operation. The runner 61 comprises a skirt 67 connected by means of vanes 68 to a crown (not shown).

A seal 69 is formed between the lowermost part of the skirt 67 and the adjacent stationary structure 62, the seal being fed with water from a suitable source of water under pressure at a point between its ends. The skirt 67 and the adjacent stationary structure define between them a space 70, and the seal 69 prevents the escape of air from within space 70 into the working fluid passage 65 at the low-pressure end of the machine. Water under pressure is fed to the seal 69 through a pipe 71 into an annular space 72 between the ends of the seal 69.

Water from the high-pressure end of the machine leaks between the rim 73 of the skirt and the adjacent stationary structure into an annular collector chamber 74, which is formed with a lip 74a to deflect the leakage water into the chamber 74 and to provide a rudimentary seal between the stationary structure and the adjacent part 73a of the skirt. The conventional peripheral seal is shown at 73b. The pipe 71 is connected to the annular collector 74, so

that water from the annular collector is delivered through the pipe 71 to the seal 69.

Air is supplied to the space 70 from a supply of air under pressure through a conduit 75 containing a restricted orifice 76. Adjacent the seal 69 the stator structure 62 is shaped to provide an annular discharge chamber 77, to which is connected an outlet pipe 78 having in it a restricted orifice 79. The annular discharge chamber 77 is freely in communication with the space 70 through a series of holes 77a at the base of and on the radially-outward side of the space 70. The annular discharge chamber 77 is also provided with a series of discharge holes 80 which communicate with the working fluid passage 65 at the low-pressure end of the machine.

The seal 69 has a lower part 69a and an upper part 69b of less extent than the lower part.

In operation the major part of the working fluid leakage passes through the gap between the rim 73 and the stationary structure 62 into the annular collector chamber 74. From this point it is delivered through pipe 71 to the seal 69, effectively sealing the gap between the skirt 67 and the stationary structure against the escape of air from the space 70 into the passage 65. Secondary leakage water passes between the lip 74a of the annular collecting chamber 74 and the adjacent part 73a of the skirt 67 into the space 70, and thence passes under the influence of gravity and centrifugal force through the holes 77a into the annular discharge chamber 77. Water passing through the upper part 69b of the seal 69 from the annular chamber 72 also passes through the holes 77a into the annular discharge chamber 77.

The supply of air through conduit 75 to space 70 effectively drives water out of this space and into the discharge chamber 77, in which the water level is determined by the air outlet pipe 78. The orifice 79 in the outlet pipe 78 has a larger area than the orifice 76 in the air supply conduit 75, thereby to ensure that the water is not driven below the level of the outlet pipe 78 by an excessive air pressure. The water in the annular discharge chamber 77 escapes through discharge holes 80, which are calibrated so that the water leaking into space 70 between the lip 74a of annular collector 74 and the part 73a of the skirt and through the upper element 69b of seal 69 is equal to the leakage through discharge holes 80.

Initially, if the space 70 and the annular discharge chamber 77 are full of water, the air supplied through conduit 75 will accumulate in space 70 at an increasing pressure, gradually emptying it of water until the conduit 78 is uncovered.

Referring now to FIG. 8, there is shown a pump, turbine or reversible pump turbine of lower specific speed design than that shown in FIG. 7; in this design the diameter of the periphery of the runner at its high-pressure end is greater than the diameter at the low-pressure end. The runner 81 rotates within stationary structure 82 about a centre-line 83. The stationary structure defines a passage 84 at the high-pressure end of the machine and a passage 85 at the low-pressure end, and the runner comprises a skirt 87 connected by vanes 88 to the crown (not shown). In this design the lower part 89a of the main seal 89 is the conventional peripheral seal of the runner. The seal 89 prevents the escape of air from the space 90 defined between the skirt 87 and the stationary structure 82. Water is supplied to the seal 89 through pipe 91 which leads to an annular groove 92 between the upper and lower elements 89b, 89a, of the seal. In this design no mechanical seal is provided between the rim 93 of the skirt 87 and the adjacent stationary structure 82, and water leaking through the gap flows into the annular collector chamber 94, from which it is delivered through pipe 91 to the seal 89. Air is supplied to space 90 through conduit 95 having a restricted orifice 96, and the part of the stationary structure adjacent the seal 89 is formed as an annular discharge chamber 97 which is connected to space 90 through a series of holes 97a. A pipe 98

containing a restrictor 99 leads out of the chamber 97 at a level above that of discharge holes 100 which communicate between the discharge chamber 97 and the working fluid passage 85 on the low-pressure side of the machine. Apart from the difference noted, the operation of the arrangement of FIG. 8 is the same as that of FIG. 7.

Referring now to FIG. 9 there is shown a turbine which is designed for a higher specific speed than that shown in the preceding figures. In this construction the runner 101 rotates in stator structure 102 about centre-line 103, and the stator structure defines a passage 104 at the high-pressure end of the machine and another passage 105 at the low-pressure end. The skirt 107 of the runner is connected by means of vanes 108 to the crown (not shown) and is of an approximately conical shape, being of larger diameter at the lower, low-pressure end than at the upper, high-pressure end. This enables a seal 109 to be formed between the lower extremity of the skirt 107 and the adjacent stationary structure, the seal being supplied with water leaking through the gap between the stationary structure 102 and the rim 113 of the upper part of the skirt 107 and then through the gap between the lip 114a and the part 113a of the skirt 107. The effects of centrifugal force and of gravity ensure that, of any mixture of air and water in space 110, the water 111 will segregate downward and outward and the air will move upward and inward, the water thus creating an effective seal 109. In this way the seal 109 has supplied to it water of which the pressure is higher than the pressure in space 110, even though the water is not supplied from outside the space. A supply of air under pressure to space 110 is provided through the conduit 115 containing a restricted orifice 116, and excess air is exhausted to waste through pipe 118 containing a restricted orifice 119, the area of which is greater than that of restricted orifice 116. The height of the inlet of pipe 118 from space 110 is chosen to ensure that there is an adequate depth of water to afford the seal 109.

The principal leakage through the gap between the rim 113 at the upper end of the skirt 107 and the stationary structure 102 flows into the annular collector chamber 114, which is provided at its lowermost point with restricted orifices 121 through which water flows to passage 122 and thence into the passage 105 at the low-pressure end of the machine.

Referring now to FIG. 10, there is shown a runner 131 rotating in stator structure 132 about a centre-line 133. The stator structure defines a passage 134 at the high-pressure end of the machine and another passage 135 at the low-pressure end of the machine. The runner comprises a crown 136 and a skirt connected to the crown by means of vanes 138.

A seal 139 is formed in this case between the crown 136 and the stationary structure 132 and is located at the radially-inner end of a space 140. The seal 139 is an elementary labyrinth seal and is fed with water by a pipe 141 at its inner end, the effect of centrifugal force making the seal effective. Cooperating with the rim 143 of the crown 136 the stator structure is formed with an annular collector 144 which is in communication with the passage 134 and therefore fills with water from the high-pressure end of the machine. Water from the annular collector 144 is delivered through pipe 141 to the seal 139.

Air is supplied to the space 140 from a source of air under pressure through conduit 145 containing a restricted orifice 146. The stator structure 132 is formed at the radially-outer end of space 140 with an annular channel 147 into which any water flowing through seal 139 is caused to flow by centrifugal force, and which also receives water flowing over a lip 144a on the stationary structure adjacent the annular collector 144. A pipe 148 for the outflow of excess air leads from annular channel 147 and contains a restricted orifice 149. A discharge pipe 150 also leads from annular channel 147 for

the discharge of water, for example that flowing over the lip 144a of annular collector chamber 144. Holes 150a are also provided in the crown 136 to allow the escape of surplus sealing water.

Referring now to FIG. 11, the pump, turbine or reversible pump turbine shown is designed for medium specific speed and differs from the embodiments already described in having a horizontal shaft. The runner 151 rotates in stator structure 152 about a centre-line 153, and the stator structure defines a passage 154 at the high-pressure end of the machine and another passage 155 at the low-pressure end. The skirt 157 of the runner is connected by means of vanes 158 to the crown (not shown). A seal 159 in this arrangement is made between the skirt 157 at the lower-pressure end of the runner and the adjacent stationary structure. The seal prevents the escape of air from a space 160, at the right-hand end of the space as shown in the drawing, between the skirt 157 of the machine and the stationary structure 152, by means of water supplied to the seal 159 through pipe 161 which delivers the water to an annular space 162 between the two ends of the seal. The main part 159a of the seal, across which the major part of the pressure difference occurs, is on the right as shown in the drawing and the other part 159b of the seal is on the left and has a smaller pressure difference across it.

Between the rim 163 of the skirt and the adjacent stationary structure is provided the main mechanical seal 163b of the machine. Leakage through this seal 163b is deflected by deflector 164a into an annular collector 164, and the deflector 164a forms a rudimentary seal with part 163a of the skirt. The water flowing under pressure into annular collector 164 is led through pipe 161 to the seal 159.

Air under pressure is lead to space 160 through conduit 165 containing a restricted orifice 166.

Instead of the annular discharge chamber used in machines having a vertical axis of rotation, in this case a discharge chamber 167 of adequate capacity is provided adjacent the lowest point of the space 160 and is connected to the lowest point of space 160 through drain pipes 167a. The level of water in discharge chamber 167 is controlled by the air outlet pipe 168, having a restricted orifice 169. The size of the orifice 169 is chosen so that the pressure in discharge chamber 167 is great enough to discharge water through pipes 170 into the passage 155 on the low-pressure side of the machine or to some other suitable point.

Referring now to FIG. 12, there is shown an arrangement which is similar to that of FIG. 5, except that instead of the pipe 181 (corresponding to pipe 21) being led direct to seal 179 (corresponding to seal 19), it is led to a chamber 187 of adequate capacity, arranged above the seal 179. Thus the chamber 187 provides a reservoir of water, which flows by gravity and under the influence of the pressure in chamber 187, through pipe 181a to the seal 179. A conduit 185 is connected from a supply of air under pressure to chamber 187 through a restrictor 186, and a further conduit 185a connects the chamber 187 to the space 180 between the crown 176 and the stationary structure 172, the conduit 185a being positioned above the water level in chamber 187. The water level is determined by a waste pipe 188 containing a restrictor 189, through which excess air, and water in excess of the predetermined level, are exhausted.

In the embodiments described the restricted orifices 26, 36, 76, 96, 116, 146, 166, 186, 79, 99, 119, 149, 169, and 189 may be made adjustable, and an adjustable restriction may be provided in the pipes 21, 31, 71, 91, 141, 161, and 181. Moreover, these pipes may be supplied from some other source of water than that shown.

It will be apparent that by keeping the spaces 20, 30, 70, 90, 110, 140, 160, substantially filled with air and free of water, the rotational losses of the runner are reduced, and the efficiency of the machine improved.

What I claim as my invention and desire to secure by Letters Patent is:

1. In a rotary fluid machine including a runner having a high-pressure end and a low-pressure end, runner blades, a shroud at the periphery of said blades, and stator structure surrounding said shroud to define therewith an annular space, said runner and stator structure defining a working fluid passage therethrough, in combination, sealing means between said runner and said stator structure at the end of said annular space adjacent said low-pressure end of the runner, said sealing means comprising co-operating parts on said runner and on said stator structure and conduit means to supply liquid under pressure to said co-operating parts whereby to prevent the escape of gas from said space between said co-operating parts, means to supply gas under pressure to said space, said stator structure including means defining an annular collector chamber adjacent said high-pressure end of the runner and further defining a deflector lip which closely surrounds and radially overlaps said shroud, whereby to deflect leakage fluid flowing between said shroud and said stator structure at said high-pressure end into said annular collector chamber, said conduit means connected to said annular collector chamber for by-passing said leakage fluid around said annular space, said stator structure further defining a discharge chamber, fluid flow means placing the lower end of said annular space freely in communication with said discharge chamber, outlet means connected to said discharge chamber to determine the liquid level therein, and discharge means communicating between said discharge chamber and said working fluid passage adjacent said low-pressure end of the runner for the discharge into said working fluid passage of liquid flowing from said sealing means into said discharge chamber through said fluid flow means, whereby said annular space is maintained substantially free of working fluid during operation.

2. In a rotary fluid machine including a runner having a high-pressure end and a low-pressure end, runner blades, a shroud at the periphery of said blades and stator structure surrounding said shroud to define therewith an annular space, said runner and stator structure defining a working fluid passage therethrough, in combination, sealing means between said runner and said stator structure at the end of said annular space adjacent said low-pressure end of the runner, said sealing means comprising co-operating parts on said runner and on said stator structure and conduit means to supply liquid under pressure to said co-operating parts whereby to prevent the escape of gas from said space between said co-operating parts, means to supply gas under pressure to said space, said stator structure defining an annular collector chamber adjacent said high-pressure end of the runner and further defining a deflector lip which closely surrounds said shroud, whereby to deflect leakage fluid flowing between said shroud and said stator structure at said high-pressure end into said annular collector chamber, said conduit means connected to said annular collector chamber for by-passing said leakage fluid around said annular space, said stator structure further defining a discharge chamber, fluid flow means placing the lower end of said annular space freely in communication with said discharge chamber, outlet means connected to said discharge chamber to determine the liquid level therein, and discharge means communicating between said discharge chamber and said working fluid passage adjacent said low-pressure end of the runner for the discharge into said working fluid passage of liquid flowing from said sealing means into said discharge chamber through said fluid flow means, whereby said annular space is maintained substantially free of working fluid during operation.

3. In a rotary fluid machine including a runner having a vertical axis of rotation, a high-pressure end and a low-pressure end, runner blades, a shroud at the periph-

ery of said blades whereof the high-pressure end is of smaller radius than the low-pressure end, and stator structure surrounding said shroud to define therewith an annular space, said runner and stator structure defining a working fluid passage therethrough, in combination, sealing means between said runner and said stator structure at the end of said annular space adjacent said low-pressure end of the runner, said sealing means comprising co-operating parts on said runner and on said stator structure and means to supply liquid under the action of gravity and centrifugal force to said co-operating parts whereby to prevent the escape of gas from said space between said co-operating parts, means to supply gas under pressure to said space, said stator structure defining an annular collector chamber adjacent said high-pressure end of the runner and further defining a deflector lip which closely surrounds said shroud, whereby to deflect a major part of the leakage fluid flowing between said shroud and said stator structure at said high-pressure end into said annular collector chamber, conduit means connected to said annular collector chamber for by-passing the major part of said leakage fluid around said space, outlet means connected to said co-operating part of said sealing means on said stator structure to determine the liquid level in said sealing means, and discharge means communicating between said sealing means and said working fluid passage adjacent said low-pressure end of the runner, for the discharge into said working fluid passage of liquid flowing from said sealing means, whereby said annular space is maintained substantially free of working fluid during operation.

4. In a rotary fluid machine including a runner having a high-pressure end and a low-pressure end, runner blades, a shroud at the periphery of said blades, and stator structure surrounding said shroud to define therewith an annular space, said runner and stator structure defining a working fluid passage therethrough, in combination, sealing means between said runner and said stator structure at the end of said annular space remote from said high-pressure end of the runner, said sealing means comprising co-operating parts on said runner and on said stator structure and conduit means to supply liquid under pressure to said co-operating parts whereby to prevent the escape of gas from said space between said co-operating parts, said means to supply liquid including a closed chamber, means to supply liquid to said closed chamber, conduit means between said closed chamber and said co-operating parts, means to supply gas under pressure to said closed chamber, and means including a waste pipe to determine the liquid level in said chamber, means to supply gas under pressure to said annular space and including conduit means connected to said closed chamber above said liquid level and connected to said annular space, said stator structure including means defining an annular collector chamber adjacent said high-pressure end of the runner, said conduit means connected to said annular collector chamber for by-passing the major part of said leakage fluid around said annular space, whereby said annular space is maintained substantially free of working fluid during operation.

5. In a rotary fluid machine as claimed in claim 4, in which connection means are provided between said con-

duit means connected to said annular collector chamber and said means to supply liquid to said closed chamber, whereby said leakage fluid is supplied to said co-operating parts of the sealing means.

6. In a rotary fluid machine as claimed in claim 2, in which said discharge chamber is annular in form and is positioned to surround said shroud.

7. In a rotary fluid machine as claimed in claim 2, in which said discharge chamber is positioned at the lowest point in said machine.

8. In a rotary fluid machine including a runner having a high-pressure end and a low-pressure end, runner blades, a shroud at the periphery of said blades, and stator structure surrounding said shroud to define therewith an annular space, said runner and stator structure defining a working fluid passage therethrough; in combination, sealing means between said runner and said stator structure at the end of said annular space adjacent said low-pressure end of the runner, said sealing means comprising co-operating parts on said runner and on said stator structure, means to supply gas under pressure to said space, said stator structure defining an annular collector chamber adjacent said high-pressure end of the runner, at a radial distance from the axis of rotation thereof and radially outward of said shroud, lip means on said stator structure to deflect liquid into said annular collector chamber and away from said space whereby liquid in said annular space is centrifuged into said annular collector chamber by said shroud during operation of said machine, and conduit means connected to said annular collector chamber and to said sealing means, whereby liquid is supplied to said co-operating parts of said sealing means through said conduit means at a greater pressure than the gas pressure existing in said annular space, to prevent the escape of gas therebetween.

9. In a rotary fluid machine as claimed in claim 8, in which said stator structure also defines an annular channel opening into said annular space just inward of said annular collector chamber, and pipe means connected to said annular channel, whereby to determine the depth of water in said annular collector chamber, and thus the difference between the water pressure generated in said annular collector chamber by centrifugal force and the gas pressure in said annular space.

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